S/N unknown

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Yamagata et al.	Serial No.:	unknown
Filed:	concurrent herewith	Docket No.:	10873.326USD1

Title: DEVICE FOR CALCULATING DIFFRACTION EFFICIENCIES OF A DIFFRACTION LENS, LENS WITH GRATING ELEMENT, AND OPTICAL SYSTEM FOR READING

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By: _____
Name: Christopher Stordahl

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D. C. 20231

Dear Sir:

In connection with the above-identified application filed herewith, please enter the following preliminary amendment:

IN THE SPECIFICATION

Please replace the paragraph beginning at page 5, line 3 with the following rewritten paragraph:

--Conventionally, particularly in order to correct chromatic aberration as a cause of deterioration in imaging performance, combinations of multiple lenses with different Abbe numbers have been used. For example, in Publication of Unexamined Japanese Patent Application (Tokukai) No. Hei 5-119255, a technology that intends to correct chromatic aberration by forming an optical system for reading using three lenses in three groups, and also to enable low-cost production by using plastic materials as a lens material is disclosed. Furthermore, in Publication of Unexamined Japanese Patent Application (Tokukai) No. Hei 5-

135193, a bar code reader, in which the optical system for reading is formed by using a single aspheric lens is disclosed.--

In addition, please replace the paragraph beginning at page 5, line 14, with the following rewritten paragraph:

--However, in the optical system for reading as disclosed in the above-mentioned Publication of Unexamined Japanese Patent Application (Tokukai) No. Hei 5-119255, due to the need for multiple lenses, low-cost production is limited in view of processing and assembly of the lenses. Furthermore, although it is intended to achieve low-cost production by using plastic materials for the lens materials, because types of plastic materials are limited, correction of chromatic aberration is also restricted. Also, in the bar code reader disclosed in the above-mentioned Publication of Unexamined Japanese Patent Application (Tokukai) No. Hei 5-135193, because chromatic aberration cannot be corrected and a single wavelength is required, a light source such as an LED is needed, thus limiting miniaturization and low-cost production.--

<u>IN THE CLAIMS</u>

Please amend claims 15 and 32 as follows:

15. (amended) An apparatus for designing diffraction lenses, comprising:

an input for entering lens design data; and

a processor for calculating optical properties and diffraction efficiencies of the diffraction lens obtained on the basis of said design data;

wherein the processor for calculating the diffraction efficiencies is a device for calculating diffraction efficiencies according to Claim 12.

32. (amended) A method for designing diffraction lenses, comprising:

an input step of entering lens design data;

a processing step of calculating optical properties and diffraction efficiencies of the diffraction lens obtained on the basis of said design data;

an optimization step of optimizing the lens properties based on the result of the processing step;

wherein the processing step of calculating the diffraction efficiencies is a method for calculating diffraction efficiencies according to Claim 29.

REMARKS

The above preliminary amendment is made to remove multiple dependencies from claims 15 and 32 and to correct a typographical error in the specification. A marked-up copy showing changes made is attached.

Applicants respectfully request that the preliminary amendment described herein be entered into the record prior to calculation of the filing fee and prior to examination and consideration of the above-identified application.

If a telephone conference would be helpful in resolving any issues concerning this communication, please contact Applicants' primary attorney-of record, Douglas P. Mueller (Reg. No. 30,300), at (612) 371.5237.

Respectfully submitted,

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DPM/CBH/jlc

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having high density, so that satisfactory correction of various aberrations is needed.

Conventionally, particularly in order to correct chromatic aberration as a cause of deterioration in imaging performance, combinations of multiple lenses with different Abbe numbers have been used. For example, in Publication of Unexamined Japanese Patent Application (Tokukai) No. Hei 5-119255, a technology that intends to correct chromatic aberration by forming an optical system for reading using three lenses in three groups, and also to enable low-cost production by using plastic materials as a lens material is disclosed. Furthermore, in Publication of Unexamined Japanese Patent Application (Tokukai) No. Hei "1-133659," --5-135193-- a bar code reader, in which the optical system for reading is formed by using a single aspheric lens, is disclosed.

However, in the optical system for reading as disclosed in the above-mentioned Publication of Unexamined Japanese Patent Application (Tokukai) No. Hei 5-119255, due to the need for multiple lenses, low-cost production is limited in view of processing and assembly of the lenses. Furthermore, although it is intended to achieve low-cost production by using plastic materials for the lens materials, because types of plastic materials are limited, correction of chromatic aberration is also restricted. Also, in the bar code reader disclosed in the above-mentioned Publication of Unexamined Japanese Patent Application (Tokukai) No. Hei "1-133659," --5-135193-- because chromatic aberration cannot be corrected and a single wavelength is required, a light source such as an LED is needed, thus limiting miniaturization and low-cost production.

SUMMARY OF THE INVENTION

To solve the above problems, it is an object of the first present invention to provide a simple method for calculating the diffraction efficiency of a lens molded with a die that was cut with a diamond bit.

It is another object of the first present invention to provide a combined refraction / diffraction lens that can be cut with high productivity using a diamond bit and which provides sufficient achromatism.

Furthermore, an object of the first invention is to solve the above-mentioned problems, and to provide a lens with a diffraction element that can be processed easily while utilizing the characteristics of conventional lenses with diffraction elements by devising the pitches of the relief rings

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M : positive integer (M > 1) indicating the number of regions for which the diffraction efficiency is calculated

m : index of the region for which the diffraction efficiency is calculated

W_m : weight for the m–th region

η_{mjl} : diffraction efficiency for the j–th order diffraction light of the m–th region at the l–th wavelength

13. A lens–shape measurement apparatus for measuring the surface shape of a measurement object selected from the group consisting of a diffraction lens and a die for a diffraction lens, the apparatus comprising:

a shape measuring means for measuring the surface shape of said measurement object;

a processor device for substantially eliminating at least one of the macroscopic components selected from the group consisting of a spherical surface, an aspherical surface, and a plane from measurement data obtained with said shape measuring means; and

a device for calculating diffraction efficiencies of the diffraction lens based on the measured data from which said macroscopic component has been substantially eliminated;

wherein said device for calculating diffraction efficiencies is a device according to one of the claims 1 to 8.

14. The lens–shape measurement apparatus according to Claim 13, further comprising:

a decision means for deciding whether said measurement object is a die or a lens; and

a data reversal means for reversing said measurement data if said measurement object is a die.

15. An apparatus for designing diffraction lenses, comprising:

an input for entering lens design data; and

a processor for calculating optical properties and diffraction efficiencies of the diffraction lens obtained on the basis of said design data;

wherein the processor for calculating the diffraction efficiencies is a device for calculating diffraction efficiencies according to one of the Claims 9 to 12." -- Claim 12 --

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wherein:

j : integer indicating the order of diffraction light

l : index of the wavelengths

E_{jl} : diffraction efficiency for j–th order diffraction light of the diffraction lens at the l–th wavelength

M : positive integer (M > 1) indicating the number of regions for which the diffraction efficiency is calculated

m : index of the region for which the diffraction efficiency is calculated

W_m : weight for the m–th region

η_{mjl} : diffraction efficiency for the j–th order diffraction light of the m–th region at the l–th wavelength .

30. A method for calculating diffraction efficiencies of a diffraction lens by measuring the surface shape of a measurement object selected from the group consisting of a diffraction lens and a die for a diffraction lens, the method comprising:

a shape measuring step of measuring the surface shape of said measurement object;

a processing step of substantially eliminating at least one of the macroscopic components selected from the group consisting of a spherical surface, an aspherical surface, and a plane from measurement data obtained in said shape measuring step; and

a step of calculating diffraction efficiencies of the diffraction lens based on the measured data from which said macroscopic component has been substantially eliminated;

wherein said step of calculating diffraction efficiencies is a method according to one of the claims 18 to 25.

31. The method for calculating diffraction efficiencies according to Claim 30, further comprising:

a decision step of deciding whether said measurement object is a die or a lens; and

a data reversal step of reversing said measurement data if said measurement object is a die.

32. A method for designing diffraction lenses, comprising:

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an input step of entering lens design data;

a processing step of calculating optical properties and diffraction efficiencies of the diffraction lens obtained on the basis of said design data;

an optimization step of optimizing the lens properties based on the result of the processing step;

wherein the processing step of calculating the diffraction efficiencies is a method for calculating diffraction efficiencies according to "one of the Claims 26 to 29." -- Claim 29 --

33. The method according to Claim 32, wherein said optimizing step optimizes aberration and diffraction efficiency.

34. A diffraction lens designed using the method according to Claim 32.

35. A computer–readable recording medium storing a computer–executable program for calculating diffraction efficiencies of a diffraction lens divided into a plurality of regions, each region comprising at least one grating ring, wherein the program executes:

a first memory step of storing information about diffraction efficiencies of said regions;

a second memory step of storing information about weights corresponding to said regions; and

a first processing step of retrieving information stored in said first and said second memory step, and calculating diffraction efficiencies of the entire diffraction lens using the formula

(1) $$E_j = \sum_{m=1}^{M} W_m \eta_{mj}$$

wherein:

j : integer indicating the order of diffraction light

E_j : diffraction efficiency for j–th order diffraction light of the diffraction lens

M : positive integer (M > 1) indicating the number of regions for which the diffraction efficiency is calculated

m : index of the region for which the diffraction efficiency is calculated